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Supply chain modularisation: Cases from the French automobile industry

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Abstract

In recent years car manufacturers have been gradually moving from the procurement of discrete parts to the procurement of modular systems. However, research into this development has not yet sought to identify how such a shift is likely to influence the operations of key suppliers within a modular supply chain and more specifically, how such suppliers are likely to interpret their respective approaches to modular provision. The aim of this research is to address these issues using a case-based approach of a modular supply chain currently engaged in supplying cockpit modules to a French car manufacturer. The findings accord broadly with research undertaken in the United Kingdom [Doran, D., 2004. Rethinking the supply chain: an automotive perspective. *International Journal of Supply Chain Management* 9(1), 102–109] which indicated that accommodating modular supply is both complex and challenging and requires a discrete set of competencies that move beyond traditional approaches to product procurement. Specifically the findings suggest that strategies commensurate with supplying on a modular basis are likely to involve an increased degree of risk sharing, a strategy for acquiring a cohesive set of supply chain management capabilities and a readiness to dispose non-core activities while acquiring those activities that will enhance modular capabilities.

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1. Introduction

The growth of modular assembly and modular development has gathered significant pace during the last decade and seems set to dominate those sectors where product complexity is high and consumer demands are constantly changing. The rate of modular growth has been attributed to a number of factors, including the potential for increased flexibility, increased speed to market and

reduced cost (McAlinden et al., 1999). Sanchez and Collins (2001) suggest that the most visible benefits of modularity are the ability to configure new product variations quickly and at low cost by mixing and matching components within modular product architecture.

Similarly Velos and Kumar (2002) note that the move toward modules within the automotive sector has been influenced by declining profit per vehicle, shorter product life cycles and the increasingly sophisticated demands of consumers in global markets. Earlier research by Langlois and Robertson (1992) centred upon the microcomputer

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industry which is, perhaps, the benchmark for modular activity and noted that:

The development of modular systems can lead to vertical and horizontal disintegration, as firms can often best appropriate the rents of innovation by opening their technology to an outside network of competing and co-operating firms. (p. 297)

However, defining what actually constitutes a ‘module’ and what constitutes ‘modularisation’ is, as yet, an area of some debate. Noting this complexity Camuffo (2000) describes modularisation as:

a vaguely defined and ambiguously used term in the auto industry...a broad concept, applicable and applied to a number of systems (product design, manufacturing, work organisation, etc). (p. 2).

Carliss et al. (1997) capture the essence of modularity which they describe as:

building a complex product or process from smaller subsystems that can be designed independently yet function together as a whole. (p. 84)

Although the above descriptions of modularity and modularisation suggest a lack of clarity and a broadness of scope, Helper et al. (1999) predict that vehicles will soon consist of self-contained functional units with standardised interfaces within one or more standardised product architectures, manufactured or supplied, and assembled as autonomous modules. In terms of developing strategies commensurate with modularity, Helper et al. (1999) suggest a number of possible modular strategies:

- Modular design for some subsystems but not where costs outweigh benefits.
- Modules that are automaker specific with OEMs avoiding or blocking industry in their design

functionality, technical standards and common interfaces.

- Only some modules outsourced with critical modules produced by the OEM, outsourcing non-modular components.

Within the automotive sector the most visible example of the trend toward modularisation is the ‘Smart’ car collaboration between Mercedes-Benz and the watchmakers Swatch. Mercedes-Benz and Swatch took an innovative design, a purpose built plant and a new supply base designed specifically to accommodate modularisation of the Smart car. Whilst a typical car manufacturer would deal with around 200–300 suppliers, the Smart car collaboration uses twenty-five module suppliers. Examples of Smart modules include complete dashboard systems, body structure, breaking control systems and seating modules. Indicative of the modular approach is the transfer from the OEM of a higher percentage of value-creating activities to upstream suppliers; at the Smart car assembly plant only twenty percent of value-creating activity is undertaken within the assembly plant. In reality, what this means to key suppliers within developing modular supply chains (particularly, tier one, tier two and tier three suppliers) is that there will be opportunities to become more involved in activities that would normally be completed by their downstream customers. So, for example, a tier one supplier may be requested by a car manufacturer (OEM) customer to undertake activities generally undertaken by the OEM, while a tier one supplier may transfer some if its non-core activities upstream to a tier two supplier, and so on. Determining what will be core and non-core activities is, perhaps, at the heart of strategic thinking within a modular supply chain and will be highlighted in the cases and discussion presented in this paper.

Much of the research concerning supply chains tends to represent such chains as a single direction relationship with value-adding activity being

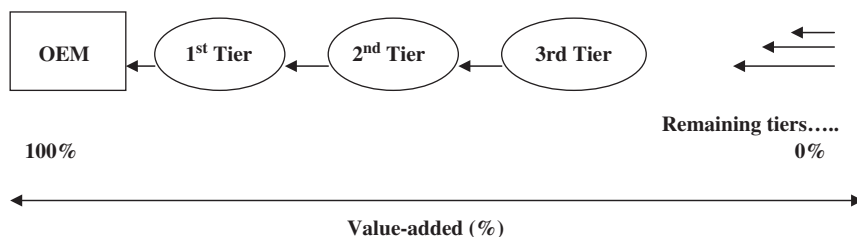


Fig. 1. Typical value chain.

accumulated toward the OEM (Fig. 1). Within a modular context the OEM, in an effort to achieve competitive advantage within an environment characterised by over capacity, is increasingly looking to focus upon core competencies and to develop strategies appropriate to its primary resources (Sako and Murray, 1999; Langlois and Robertson, 1992).

Such strategies, according to Doran (2004) have led to the development of value transfer activity (Fig. 2). Value transfer activity (VTA) reflects a chain-like transfer of value-adding activities to upstream suppliers as each operation (OEM or supplier operation) seeks to focus upon those activities viewed as core to modular manufacture/supply. VTA is, perhaps, a reflection of the need for suppliers to reorganise operations activities in an effort to accommodate the increased levels of production and management (particularly Supply Chain Management) activities passed down from the OEM or module assembler and the subsequent cascading of value creating activities to 2nd, 3rd or 4th tier suppliers. To summarise, the benefits associated with modular provision seem to relate primarily to the increased ability to accommodate new product variations in a shortened life cycle environment and at lower cost, representing changes in both market structure and market demands. While there are a number of different modular strategies available to OEMs and suppliers the ultimate long term aim of the modular approach within the automotive sector is the production of

self-contained functional modules with standardised interfaces that can be fitted across vehicle brands and across geographic locations.

2. Methodology

The primary purpose of this research is to assess the impact that modular supply has had upon four key suppliers within a developing modular supply chain and in so doing mirrors the research logic adopted in an earlier United Kingdom (UK) study (Doran, 2004) which explored the dynamics of supplying within a developing modular supply chain. The research examined the key issues associated with supplying on a modular rather than a non-modular basis and sought to determine and codify the issues facing suppliers positioning themselves to supply on a modular basis. The findings from the UK research indicated that supplying on a modular basis presented a number of challenges for suppliers at the 1st, 2nd and 3rd tier levels which led to considerable operational change and the need to consider strategic implications associated with modular supply. Of particular note was the apparent need for suppliers close to the OEM to focus upon those activities seen as key to modular supply while transferring to upstream suppliers those activities regarded as low value-adding, non-core activities.

In line with the UK study a case base approach has been utilised for the French research which

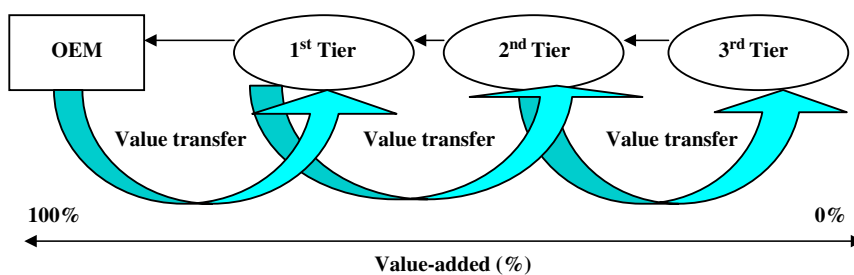


Fig. 2. Value transfer activity.

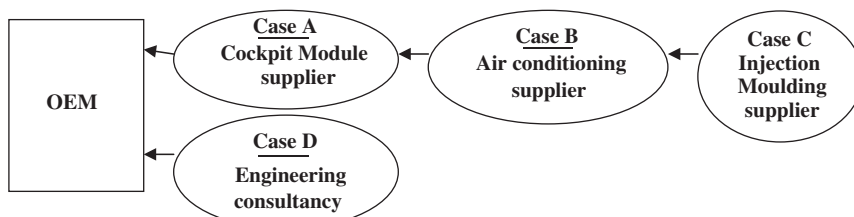


Fig. 3. French case study operations.

defines the unit of analysis (Yin, 1994) as the key suppliers within the developing modular supply chain. The basis of supplier selection related primarily to the degree of value creation activity (the combined value created by these suppliers is in excess of 50% of the total module value) and to the closeness of such suppliers to the car manufacturer; closeness in this regard is determined as a proxy for production criticality (Fig. 3). A number of semi-structured interviews were undertaken with staff at each supplier operation representing managerial and operational employees and concentrating upon how such interviewees viewed the development of modular supply and how modular supply has impacted upon their respective operations.

3. Findings

The findings will commence with a case summary of each supplier, which is then followed by an analysis of the case operation's approach to modularisation.

3.1. Case A: cockpit module supplier

3.1.1. Case summary

The supplier was created in the late 1990s through a Joint Venture (JV) between two major European automotive suppliers. The main aim of the JV is to respond directly to the modularity logic for automotive cockpits by combining the specific competencies in interior systems and electronics of the two founding companies.

The supplier operates on a just in time basis with all its OEM customers in order to deliver complete cockpits modules ready to be assembled into the vehicles. Although global developments are being considered, its customers are primarily European car manufacturers. Apart from the final assembly of the cockpit module, all manufacturing activities (plastic injection/moulding, electronics, small assemblies, etc.) are left to lower-tier suppliers. The supplier also manages most of the upstream supply chain (logistics, procurement, payment of sub-suppliers, etc.), as well as providing Research and Development (R&D) and system integration capabilities.

3.1.2. Approach to modularisation

The JV has been established with a clear focus on modularity. The supplier's only products are the

cockpit modules that it delivers fully assembled to the OEM.

The Serial Support Manager stated that:

One hundred percent of our activity is modular. In fact, it is part of the company's mission that the company will remain focused only on the modular activities linked to the particular cockpit module.

The company is involved at all stages of product development (design, assembly, quality assurance, synchronous delivery, etc.) and has developed an extensive knowledge of all aspects of the cockpit module and of project management associated with modularisation.

Because of our focus, all our operations are of course largely influenced by the modular strategies [of the OEM]... In terms of SCM, this means that we developed and acquired the ability to manage complete cockpit projects. Our major task is to integrate hundreds of sub-suppliers to work more efficiently together on each project. We describe that as 'managing the complexity', as our task is to simplify the interface between the OEMs and all those suppliers.

This approach allows the module supplier to take responsibility for most of the upstream SCM. While the OEMs keep control of the choice of the lower-tier suppliers, the cockpit supplier undertakes all other SCM activities. On each cockpit, the supplier has to manage several dozens sub-suppliers.

At the R&D level, the supplier also "manages the complexity" given that it is responsible for all the interfaces between the elements of the cockpit and the definition of the interfaces between the cockpit and the rest of the vehicle:

Although on the first projects we were only managing manufacturing aspects, we are now able to provide a complete solution to our customers: from R&D to final assembly of the cockpits into the car. We are able to link the OEM's architect knowledge to the suppliers' specific component expertise; and that is in fact our main task in R&D: define the correct interfaces inside the cockpit to optimise the work of each sub-supplier.

The manufacturing activities undertaken by the supplier only involve the final assembly of the cockpit module and all cockpits are delivered on a synchronous basis (often delivered within less than

30 min), “right first time,” and to the final customers’ specifications. To allow for synchronous supply, all production sites are located near the OEM’s production sites or, in some cases, within the OEM’s facilities. Additionally, the supplier is responsible for cockpit quality and fully tests all cockpits before despatch to the OEM. The company’s involvement in design has allowed some elements of standardisation across their different customers, especially across the different brands of the same car manufacturers.

Our expertise has been acquired along numerous projects with many car manufacturers. We have developed a strong expertise on the cockpit module... which now allows us to transfer this expertise on new projects. As we work with many OEMs, we are also able to standardise some hidden components, such as the steering column, between several OEMs.

While standardisation is limited, the supplier’s work with many different OEMs has permitted a degree of standardisation for some hidden parts (e.g. airbags, cross-car beam, etc.). Despite these limitations to standardisation, modularisation is presented by the supplier manager as a very beneficial approach:

In the car cockpit sector, the modular approach has been beneficial for every aspect: cost, delivery time, development time, cockpit weight; and we have not faced any major issue. If we could not deliver all these improvements, the OEMs would bring back these activities in-house.

These potential developments of new modular activities highlight the groups’ confidence in the future growth of modular procurement by OEMs. The interviewed manager believes not only that more and more cockpits will be supplied on modular basis, but that modular supply will be extended to an increasing number of components in each car. The modular supplier’s primary focus is therefore the management of the complexity associated with car cockpits both in the development and production stages. A key element of the supplier’s responsibilities is supply chain management; such management extends to the next case study operation.

3.2. Case B: air-conditioning assembler

3.2.1. Case summary

The assembler is part of one of world’s top automotive suppliers which is present on all continents (Europe, North America, Japan, and emerging markets) and is positioned as a major component supplier focusing on design, production, and sales to OEMs. The supplier has contracts with all major OEMs and produces electrical and thermal systems as well as transmission components on a global basis.

The plant visited for this research produces instrument panels for climate control (plastic injection of the panel faces and assembly with panel electronics). In addition to its important production capabilities, the supplier has extensive R&D capabilities in its numerous technical centres. Innovation appears to be a critical aspect of the company’s policies and R&D expenses represent more than 5% of the group’s income.

3.2.2. Approach to modularisation

The development of a modular approach appears to be very recent. The supplier is only involved in small sub-assemblies (e.g. air conditioning instrumentation vs. complete cockpit for Case A) and still focuses primarily on the components it produces in-house and has developed only limited SCM capabilities that could allow the management of larger modules (involving more sub-suppliers).

Within the company, two department managers were interviewed: one responsible for first-tier business, and one responsible for second-tier business. The first-tier business manager pointed out the company’s general approach to modularisation:

We still largely supply the OEMs directly. However, and in this plant in particular, a lot of our products are actually delivered to modular suppliers assembling the components on complete cockpit modules. The products we still deliver directly (to the car manufacturers) are complete air-conditioning systems.

The supplier feels that it has been left behind in the race to accommodate modularity.

It is difficult to start a modular strategy while there already many suppliers positioned in this market. To catch up on this increasing trend, we will have to use our main strengths: we are a large global supplier, and this will allow us to deliver

all the cost saving promises of the modular approach.

The supplier is currently redefining its position regarding modular supply; several low value-adding activities (e.g. plastic injection/moulding) are being transferred to lower-tier suppliers while gathering its activities around a few core businesses and investing heavily in the development of new technologies:

Many of our European plastic injection plants have already been sold... We are concentrating our activities around our core expertise: thermal and electrical systems and we intend to remain a leader in those fields thanks to important technological developments.

Indeed, the uniqueness of its technologies allows the supplier to maintain a leading position in many fields. For example, the early development of ultrasonic parking assistance systems has permitted the supplier to impose its standards and to dominate this specific market. Whilst the supplier makes efforts to develop modular supply, its lack of SCM capabilities and its general lack of flexibility make it difficult to develop its modular offering.

A manager of the company summarised these points

Whilst the modular supply model will probably become dominant in some areas such as cockpits, front and rear ends, engine/powertrain we are currently developing the capabilities to undertake such projects. First we have to overcome a number of internal obstacles to allow the company to evolve in this direction.

The supplier has extended R&D and production capabilities in its area of expertise. Its recent modular approach has been difficult to implement because of the company's general lack of flexibility. The supplier is progressively taking responsibility for larger sub-assemblies, which has changed the nature of its relationships with its sub-suppliers; such an enlarged role has led to changes in the supplier's relationship with the next supplier operation—Case C.

3.3. Case C: injection moulding supplier

3.3.1. Case summary

This supplier is one of the largest European specialists of plastic injection/moulding and oper-

ates in Hungary and France. Over 40% of its activity is related to the automotive industry. The French plant visited for this research works only in the automotive industry and was bought from an automotive supplier (case B) a few years ago and, at the moment, works only for this supplier. The supplier has not developed SCM or R&D capabilities and work is carried out on a “build to print” basis (i.e. the supplier produces according to specifications defined by its customers). The production expertise allows very low reject rates which is in line with other suppliers in the same field.

3.3.2. Approach to modularisation

The supplier does not seem to have any specific approach regarding the modularisation of the supply chains in which it is involved. Almost all of the supplier's products are now part of a modular supply chain, which has resulted in the supplier moving from second-tier to third-tier within this modular supply chain. The logistics manager who participated in this research summarised the company's approach to modularisation:

At the moment, all our products go through a modular supplier that assembles them on a cockpit before delivering them to the car manufacturers... In fact, the components we inject are first assembled on the steering switches (a small sub-assembly) by a large second-tier supplier, and then passed on to the modular supplier that assembles the cockpit.

Although this has increased the pressure on price by their downstream clients, the overall impact upon the business has been low and the supplier has felt little effect of the move to modularisation. Its only customer remains the same: the upstream supplier (here, case B).

The modularization of the supply chain in which we are involved has had very little influence on our operations... and has not raised any particular issue.

The supplier has, however, started a process of identifying key value-adding activities; parts painting, for example, which is outsourced to a sub-supplier is likely to be integrated to the company's core activities in order to increase the in-house value contribution.

The supplier's management team is considering this type of acquisition but remains conscious of the importance of the company's flexibility. The logistics

manager insists on the influence modularisation has had on the company and its future:

Although modularization did not change the nature of our business, it forces us to reconsider our positioning. We must always add more value to our customer: to do so, we will have to bring in-house operations such as painting which are at the moment outsourced... This must be done without deteriorating the company's flexibility.

The supplier is also considering sending more work to its Hungarian facility, and sending more work to their future North African facility (near a future OEM's site). Such choices, which require important investment, are only taken when secured with term contracts.

3.4. Case D: engineering consultancy

3.4.1. Case summary

This supplier is one of Europe's largest engineering consultancies with over 3000 staff specialised in vehicle development projects. The consultancy group is based in Germany but now operates throughout Western Europe and North America in facilities close to its primary OEM customers. The type of work undertaken has evolved considerably over the last ten years; from providing testing capabilities a decade ago, the company is now able to provide complete engineering solutions for the development of complete vehicles. The supplier also takes advantage of the trend toward more car variants based on the same platform and has positioned itself as a partner to those OEMs that require engineering consulting operations for complete vehicle projects.

As part of this 'total solutions' approach the supplier has developed technical competencies in electronics and safety systems as well as enhancing and developing its project management capabilities.

3.4.2. Approach to modularisation

The supplier works on several module development projects (approximately 30% of the company's revenues). The development of car variants (e.g. convertible, Sports Utility Vehicles, station wagon, etc.) from a single platform is becoming a key activity. The head of the mechanics department interviewed for this research emphasises the direction taken by the company:

An engineering consultancy like ours can no longer be perceived as a simple 'testing expert'...

A large part of our business is the design and integration of modules, and increasingly, the development of complete vehicles, including the management of supplier and OEM teams throughout the development stages.

Furthermore, despite the absence of production capabilities, the company is developing SCM competencies in order to be able to control all process stages along the value chain during vehicle development.

The supplier takes advantage of its small size (compared to the OEMs) to be flexible and agile, which allow it to respond quickly to the OEMs for their technical developments.

The manager points out the importance of modularisation and its advantages:

In a modular context, we are given the full development responsibility of sub-assemblies. We can therefore use our wide range of expertise to provide complete solutions in compressed development times... The platform strategy, which is essentially a 'chassis module', provides us with the opportunity to develop complete vehicles. This means that we must have all the necessary competences.

The manager adds:

It has taken us years to develop all those competencies. We are now able to design a vehicle as well as a car manufacturer would, but in an even more reduced time thanks to our flexibility and expertise. Today, we can design an entire vehicle from scratch and manage all developments up to production launch. Some specialist companies can design the engines, powertrains, electronics, and so on; Magna Steyr, for example, can undertake the entire production and assembly... A car can go out on the road without anything else from an OEM than the launch decision and the brand name... There are a few examples of such cars, and this trend will increase in the future.

The supplier offers the OEMs the possibility to develop more car variants quicker. More competencies are currently being acquired to be able to offer even more technical integration and complete project management. The supplier seems confident that the trend toward more car variants on each platform will grow and will offer more opportunities.

The manager insists on the potential growth of the modular approach:

Our wide range of technical competencies and project management expertise gives us a unique position. If we can provide a complete solution, the car manufacturers will find no interest in bringing back in-house such projects, and therefore, the module approach will increase in importance in the future.

The engineering consultancy has developed the various competencies needed to undertake the development of complete vehicles and manage the numerous suppliers in these development stages.

Table 1 summarises modular activities amongst each of the case suppliers.

4. Discussion

The primary purpose of this research has been to determine how modularisation influences the opera-

tions of key suppliers and how suppliers view their respective roles within a developing modular supply chain. The findings suggest that accommodating modular supply involves complexity, a need to focus upon core activities and the ability to recognise and reorganise activities that are not regarded as critical to the supply of modules. Case A (the module cockpit supplier) is a clear example of a supplier that has positioned itself to provide modular solutions for OEMs with a coherent strategy for organising value and developing the supply chain management skills necessary for the organisation and delivery of modular solutions. Case B, however, is a newcomer to modular supply and recognises the need to focus upon core competencies and has engaged in value transfer activity. However, location and people management issues appear to inhibit moves towards modular supply. Case C is a supplier of a commodity item and is not a key player within this modular supply chain; it seems likely that such a supplier may be consumed by product compatible 1st or 2nd tier suppliers wishing to enhance

Table 1
Modular issues

Supplier	Degree of modular activities	Evidence of modular positioning
Case A—cockpit module supplier	High	Mission focussed upon modular logic Has developed extensive knowledge of all aspects of modularization Takes responsibility for upstream SCM Ability to provide complete solutions for OEMs Located close to OEMs in order to facilitate synchronous supply Moving toward modular standardisation
Case B—air conditioning supplier	Low	Only involved in small sub-assemblies Limited SCM capabilities Delivers to module suppliers rather than directly to the OEM Has engaged in value transfer activity Currently developing a strategy to increase modular offering
Case C— injection moulding supplier	Low	Has felt little impact of the move to modularisation by its upstream customer Has started to identify areas where value can be added to its current offering Little involvement in SCM Moved from 2nd to 3rd tier positioning within the supply chain
Case D—engineering consultancy	High	Facilities located close to OEMs Able to provide complete engineering solutions for the development of complete vehicles Works on several module development projects Focus is upon the design and integration of modules Developed its SCM competencies Given full development responsibility by the OEMs Offers the OEMs the possibility to develop more car variants quicker

their modular offerings. Case D—the engineering consultancy—is clearly focussed upon modular supply and has developed its expertise in providing complete modular project solutions. It would appear that such modular engineering operations are likely to play an increasing role in managing the complexity associated with modular supply and dealing with supply chain integration issues associated with the move toward modular supply.

The research findings accord with the benefits of modularity outlined by [Sanchez and Collins \(2001\)](#). However, such benefits would appear to be clustered between two relationship strands—that of the OEM and the module assembler and that of the 1st tier suppliers and the module assembler. The findings from this research suggest that the impact and the benefits associated with modularisation naturally dissipate as one moves towards 2nd and 3rd tiers of the supply chain. This said, one can also observe that those suppliers that might be regarded as distant from the modular epicentre are modularising to a lesser degree by examining value transfer activity and value creation activities that, in their own way, could be regarded as modular activity, albeit at a more localised level. The findings also demonstrate that the issues of complexity noted by [Camuffo \(2000\)](#) and [Carliss et al. \(1997\)](#) were evident to some degree; however, those suppliers that clearly see modularisation as a future operations model tended to view modularisation in a more holistic manner and were positioning themselves to provide solutions which reduce the complexity associated with the modular logic while moving toward what [Helper et al. \(1999\)](#) described as “self-contained functional units with standardised interfaces within one or more standardised product architectures, units conceived, manufactured or supplied, and assembled as autonomous “modules.” In many respects the French case studies broadly followed the findings of the UK-based research ([Doran, 2004](#)), particularly in terms of the development of SCM capabilities of suppliers close to the OEM (cases A and B) and the focus upon identifying key value-adding activities and transferring non-core activities to upstream suppliers ([Table 1](#)). Perhaps the key difference between the findings from the UK study when compared to the French study is the important role played by the engineering consultancy (Case D). It seems apparent that as manufacturing suppliers continue to concentrate upon key module activities the role played by engineering consultancies is likely to grow and will encompass a variety of activities that would have been regarded as key supplier activities less than five years ago—

particularly in terms of full module engineering solutions, development of SCM capabilities and the responsibility to provide complete engineering solutions for the development of complete vehicles.

5. Implications and limitations

The implications associated with the development of modules are likely to be manifest in a number of ways and in a number of areas. Firstly, the modular logic necessitates a new type of supplier—a supplier that can ‘manage the complexity’ associated with intricate products and can also manage those upstream suppliers that contribute to the various elements that constitute a module. In addition, as OEMs continue to transfer value to module assemblers it is likely that such suppliers will in turn seek to transfer non-core elements of their activities to 2nd and 3rd tier suppliers, resulting in what can be termed value transfer activity. Examining the impact of modularisation through a macro-economic lens it seems apparent that there will be shifts in the location of suppliers as well as clustering and merging of suppliers that possess module complementarities. On a more general level, it would appear that modularisation is likely to require a shift of research focus, particularly in terms of issues relating to buyer–supplier relationships and issues relating to the debate concerning lean and agile production (again the debate may move from its current OEM focus to a focus upon those suppliers that supply high value modules and are in effect charged with managing production).

While the above findings indicate that modularisation has a significant impact upon various elements of modular supply chains one must note that this research presents the findings of an examination of a single supply chain and as such does not attempt to suggest that the findings are universally applicable across the sector nor are they likely to determine the approach adopted for different modules within different OEMs in different locations. Moreover, the automotive sector as a whole does not have an industry view on what constitutes modularity and does not appear to be moving toward the modular ‘plug and play’ approach adopted in the computer sector where modules are completely interchangeable.

Appendix A

See [Fig. A1](#).

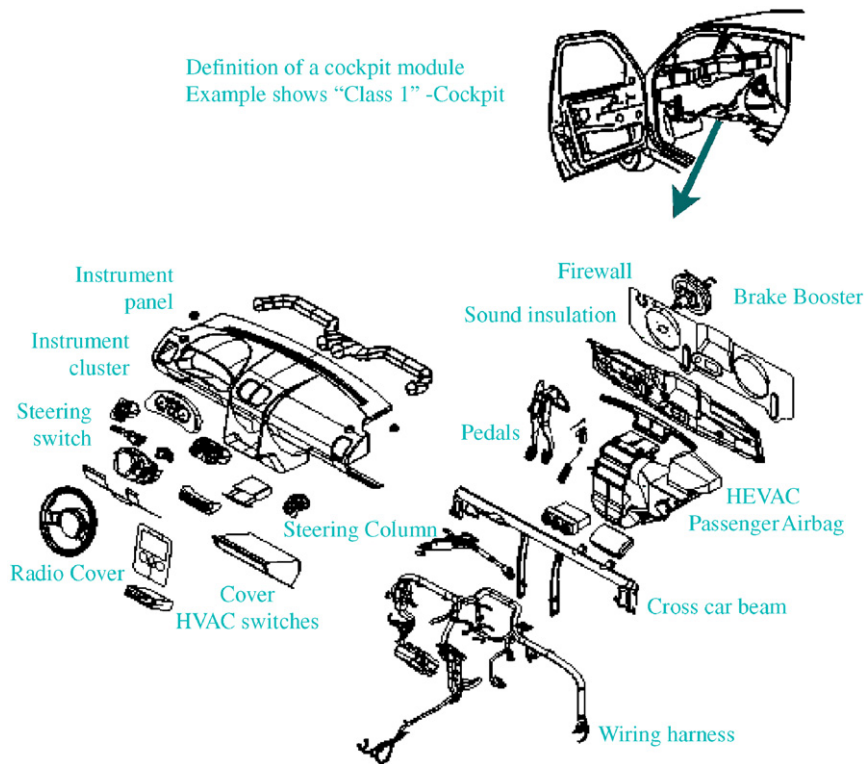


Fig. A1. Definition of a cockpit module. Example shows “Class 1”—cockpit.

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